Overview of Run II Goals, Current Performance, and Issues

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Director's Review of Run II
October 17, 2002

Outline

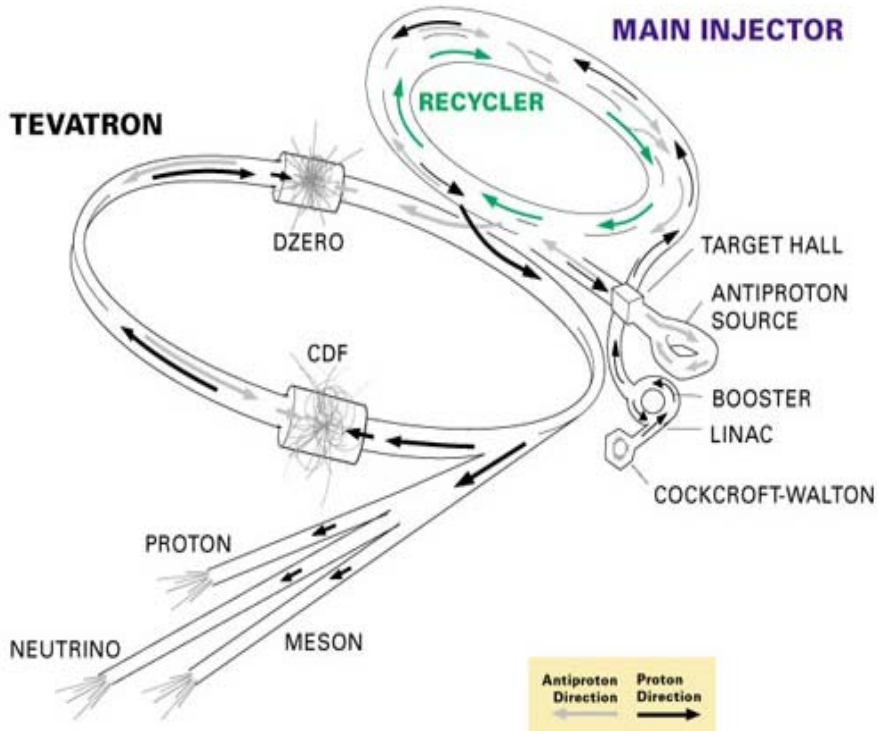
- Run II Goals
- Current Performance and Issues
- Luminosity in 2003
- Run II Beyond 2003
- Scope of our Presentations

Run II Goals

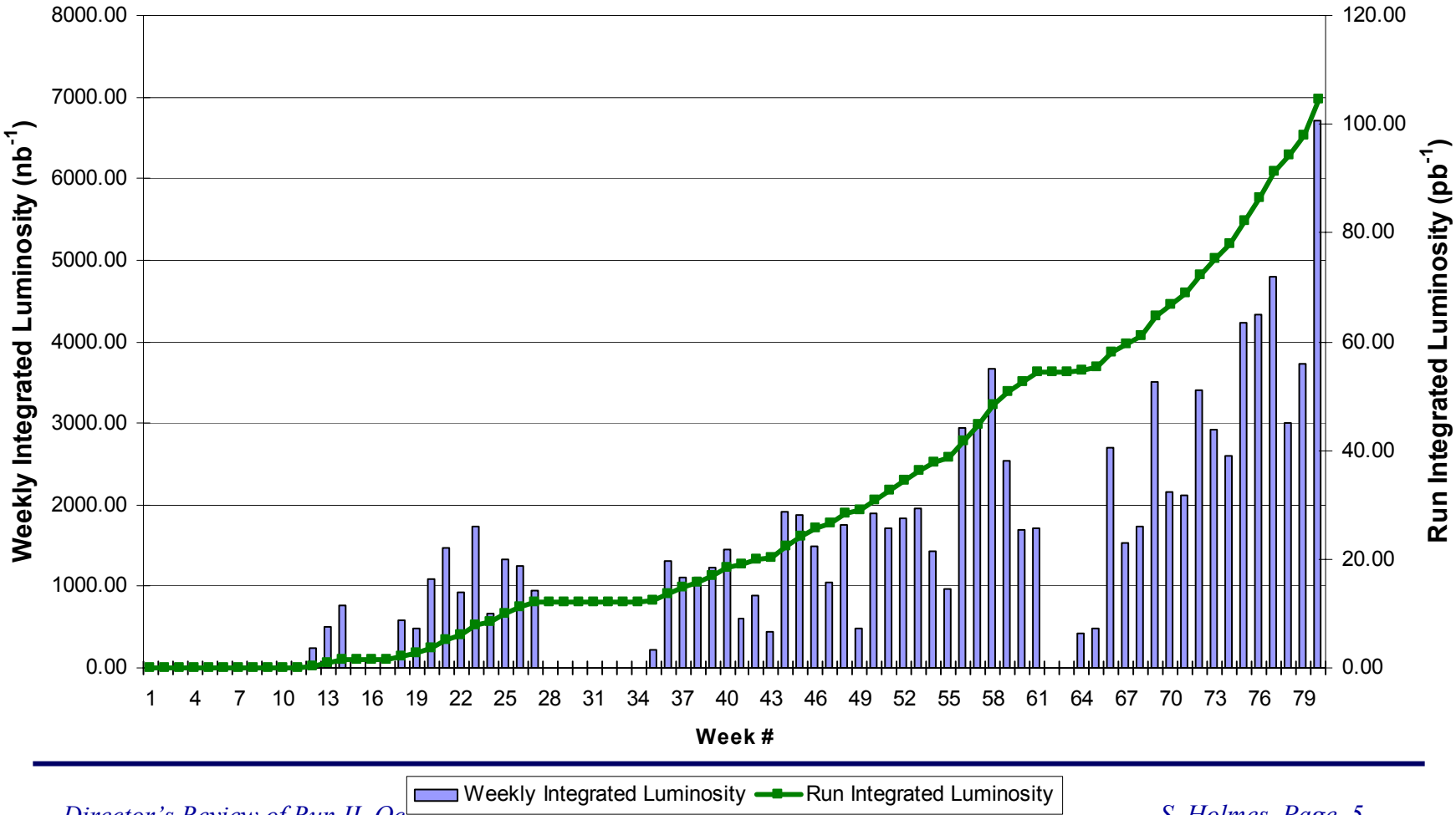
- Run IIa has referred to operations supported by the collider configuration envisioned during the Main Injector construction.
  - Luminosity:
    - 5×10^{31} (Main Injector Construction Project Data Sheets)
    - 8×10^{31} (advertised when we exceeded our Run I goal by 60%)
    - 2×10^{32} (advertised when Recycler Ring incorporated into the Main Injector Project)
  - Integrated luminosity: 2 fb^{-1} over a 2-3 year period
- Run IIb has referred to this configuration augmented by a number of (substantial) hardware upgrades required to push the luminosity above 2×10^{32} and to support a total accumulation of up to 15 fb^{-1} prior to LHC data taking.
- We will be eliminating the Run IIa/IIb distinction

Current Performance
Accelerator Configuration

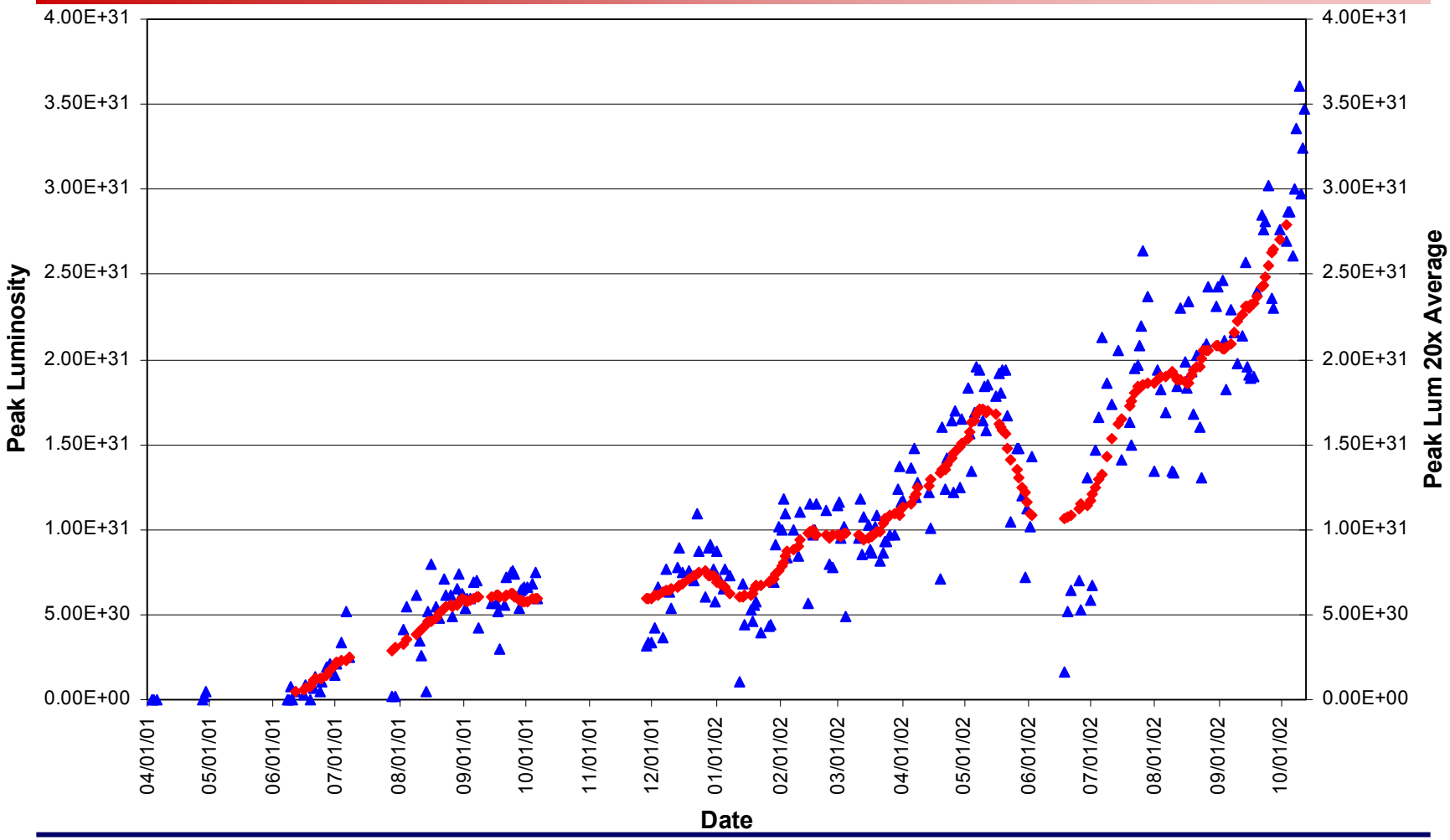
- All major hardware associated with Run IIa is in place:
  - Main Injector running close to design goals for proton and antiproton intensities
  - Recycler is in commissioning, not in use in collider operations at the moment.
  - Antiproton Source lattice and stochastic cooling upgrades are running close to design goals
- A number of hardware improvements, identified in initial Run II operations, are still to come.



Current Performance
Integrated Luminosity (through 10/13/02)



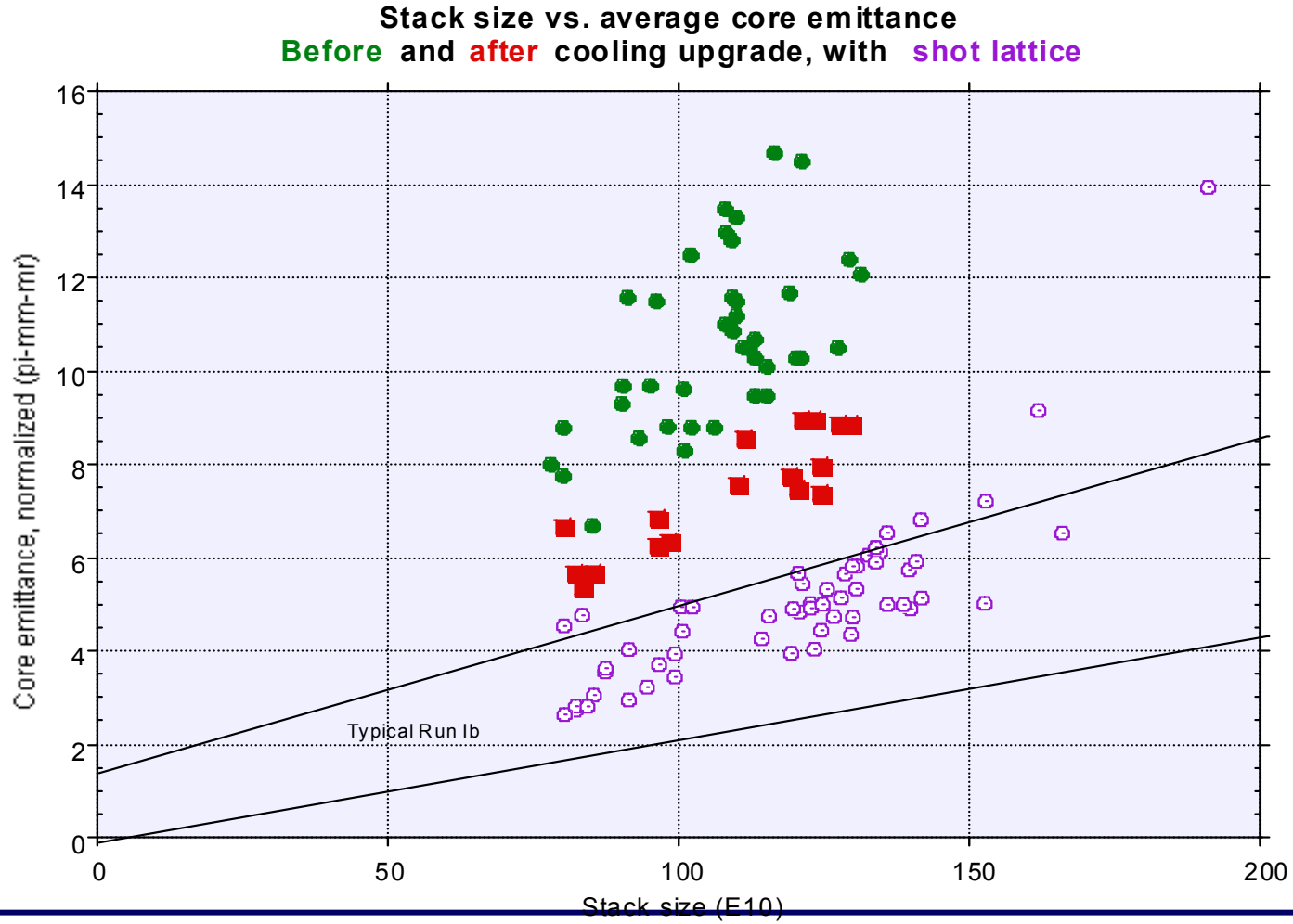
Current Performance
Initial Luminosity (through 10/13/02)



Current Performance
Modifications to the Complex

- Every improvement in luminosity performance has been associated with a specific modification to the accelerator complex. Major modifications since January 1, 2002:
  - Accumulator->Main Injector transfer optics
  - Adjustment of tunes and helix during low beta squeeze
  - Modified injection helix
  - Proton beam loading compensation in Main Injector
  - Accumulator (stochastic) cooling upgrade
  - Accumulator shot lattice
  - Antiproton beam loading compensation in Main Injector
  - Tevatron beam line tuner (BLT)
  - Tevatron tune/coupling drift compensation
  - Tevatron (horizontal) dampers
- **Note: $(1.15)^{10} = 4.0$**

Current Performance
Modifications to the Antiproton Source



Current Performance
Comparison with Run IIA Goals

(http://www-bd.fnal.gov/lug/runII_handbook/RunII_index.html)

	Run IB	RunIIA Goal (wo/ recycling)	RunIIA (achieved*)	
Protons/bunch	2.30E+11	2.70E+11	1.73E+11	
Antiprotons/bunch	5.50E+10	3.00E+10	2.38E+10	
Total Antiprotons	3.30E+11	1.08E+12	8.55E+11	
Antiproton Production Rate	6.0E+10	2.0E+11	1.2E+11	$hour^{-1}$
Accumulator->150 GeV efficiency	0.80	0.90	0.83	
150 GeV -> low β efficiency	0.80	0.90	0.78	
Accumulator -> low β efficiency	0.64	0.81	0.65	
Proton emittance (95%, norm)	23	20	20	πmm-mr
Pbar emittance (95%, norm)	13	15	15	πmm-mr
Beta @ IP	0.35	0.35	0.35	m
Beam Energy	900	1000	980	GeV
Bunches	6	36	36	
Longitudinal Emittance (protons)	5	3	6	eV-sec
Longitudinal Emittance (pbars)	5	3	4.5	eV-sec
Form Factor (Hourglass)	0.59	0.70	0.63	
Typical Luminosity	1.6E+31	8.08E+31	3.61E+31	$cm^{-2}sec^{-1}$

*"Achieved" refers to best simultaneous performance. Best individual parameters are higher.

Current Performance

- Current **antiproton production rate is sufficient** to support a luminosity in the **4-6x10^{31} cm^{-2}sec^{-1}** range.
- Protons are roughly 64% of Run II goal
- Antiprotons are roughly 79% of Run II goal
  - Transfer efficiency accumulator to low beta is 60-70% (depends on stack size). Our goal is 80%, but this performance is significantly improved from earlier in the year.
- Current performance is now well beyond that of Collider Run IB
  - A factor of four improvement since January 1, 2002.
  - While we are very happy with the current pace of progress, we recognize that overall performance this year has been disappointing to the laboratory, to our users, and to the HEP community.

Current Performance

Issues

- Protons
  - MI longitudinal emittance
  - MI->Tevatron transfer efficiency (90%)
  - Tevatron lifetime at 150 GeV (<2 hours)
  - Tevatron acceleration efficiency (90%)
  - Tevatron beam instabilities setting in at ~200E9.
- Antiprotons
  - Emittance dilution on MI->Tev transfer (40-80%)
  - Tevatron 150 GeV lifetime (< 2 hours)
  - Tevatron acceleration efficiency (90%)
- Underlying Causes
  - Apertures, matching, instabilities, long-range beam-beam

Current Performance
Short Term Strategy/Goals

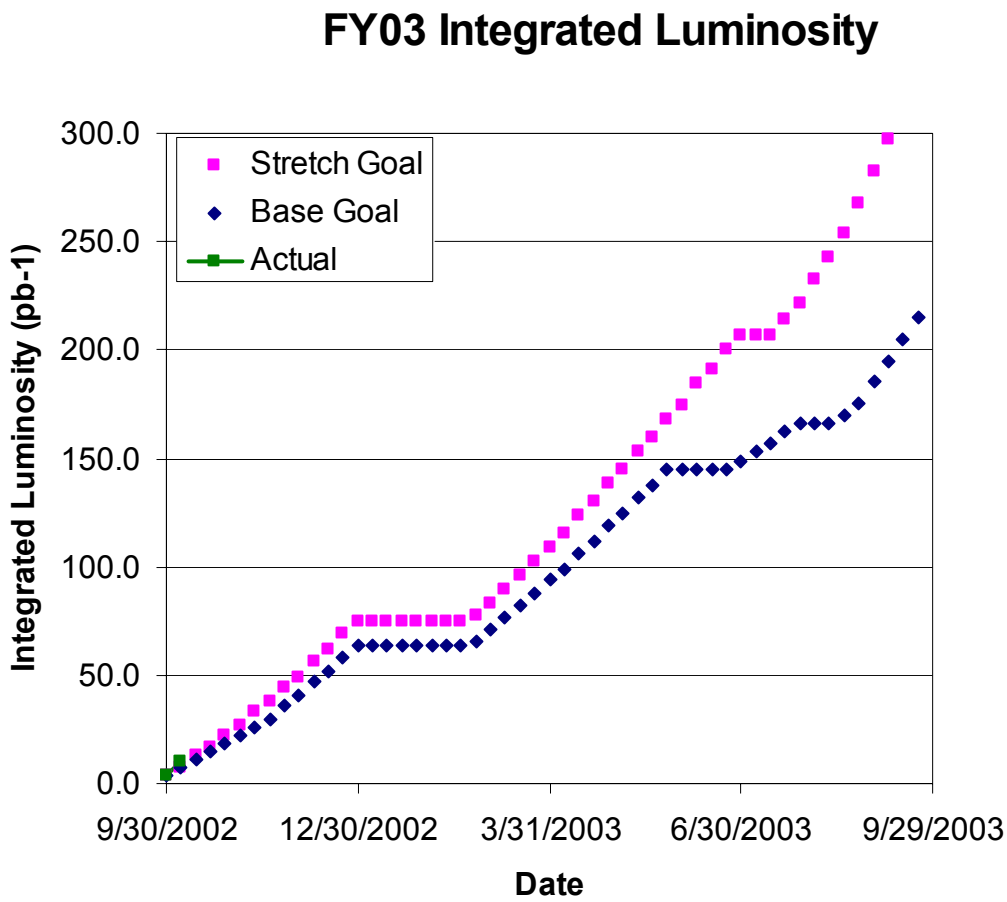
- Even with a factor of four improvement we are still considerably behind the plan established on January 1 for Tevatron performance this year
  - Factor of 1.6 in peak, factor of 2 in integrated luminosity
  - Elements of the plan are sound, implementation times underestimated
- We have established a short term goal of getting to $4x10^{31}$ $cm^{-2}sec^{-1}$ this fall.
  - Relies primarily on initiatives in emittance preservation and dampers.
  - Success will allow integration of 100-150 pb^{-1} for the year 2002

Luminosity in 2003

- A complete scope of work and associated resource loaded schedule has been created for FY2003. General strategy:
  - Run through December with studies scheduled every other week.
    - Expect to maintain typical luminosities in the range 2.5-4E31
    - MiniBoone running in parallel
  - Execute 6 week shutdown some time in the winter/spring
    - Make Recycler ready to contribute to luminosity
    - Replace C-0 Lambertsons (with MI dipoles)
    - NuMI installation activities
    - Lots of (deferred) maintenance
  - Run with no additional major shutdowns through summer of 2003
    - Expect to achieve initial Run II luminosity goal of 5-6E31
    - Integrate Recycler into operations
    - Electron cooling civil construction in parallel
    - MiniBoone running in parallel

Luminosity in 2003
Goals and Projections

- Integrated luminosity projections:
  - We have established a range of expectations for integrated luminosities as part of the FY03 plan.
  - Base goals:
    - 200 pb-1 for FY03
    - 10 pb-1/week by the end of the year
  - Stretch goals:
    - 320 pb-1 for FY03
    - 15 pb-1/week by the end of the year



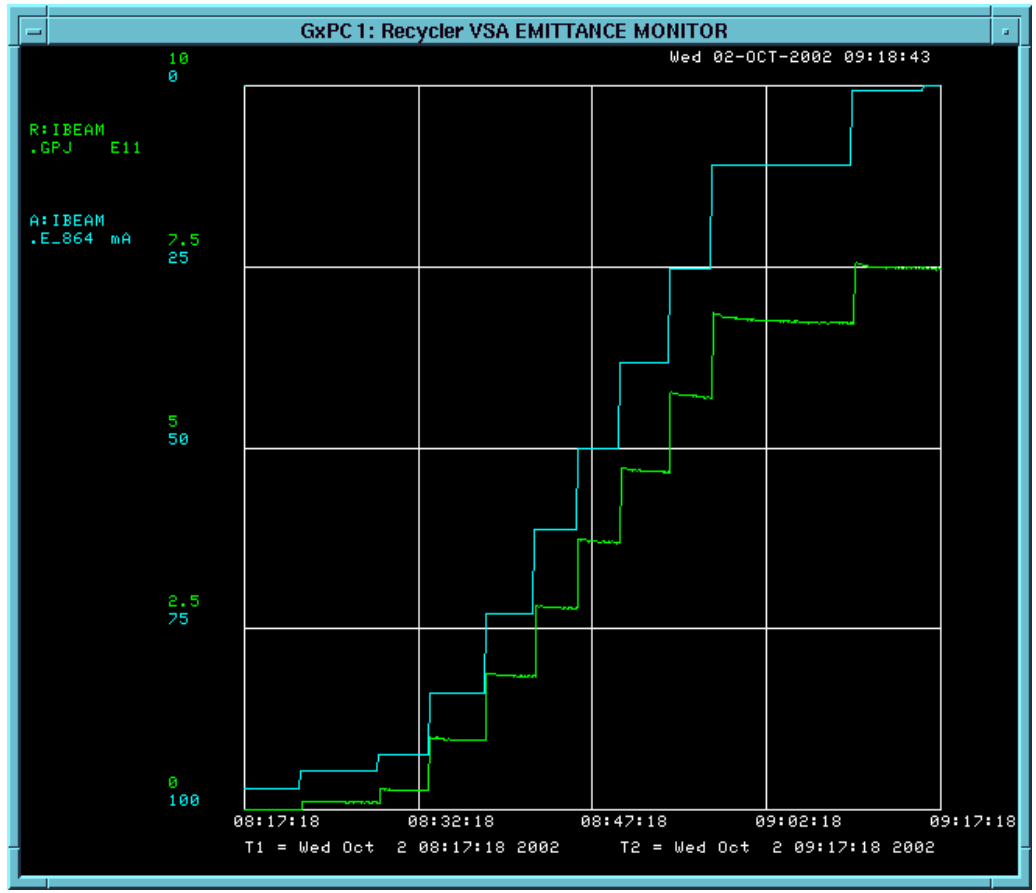
Run II Beyond 2003
Strategy and Planning

- We believe the current accelerator configuration is capable of producing somewhere between 6-8x10^{31} $cm^{-2}sec^{-1}$.
  - Achieve in late 2003/early 2004
  - Integration of the Recycler should move this up to 8-10E31
- A number of improvements have been identified with a goal of pushing luminosity into the range 2-4x10^{32} $cm^{-2}sec^{-1}$.
  - **Operational Recycler is a pre-requisite**
  - Published Run IIb "Plan" in December 2002. Major elements:
    - Proton accumulation (slip stacking) in Main Injector
    - Antiproton yield improvements
    - Antiproton stochastic cooling improvements
    - Electron cooling in the Recycler
    - Tevatron beam-beam compensation
  - Very little work has been invested in this plan beyond electron cooling

Run II Beyond 2003
Recycler

Antiproton Stacking in the Recycler showing:

- 78% stacking efficiency
- 7.5E11 stack
- 110 hour lifetime with cooling on and Main Injector ramping
- <10π transverse emittances with cooling on.



Scope of our Presentations

- Primary focus of our presentations will be current status and plans for bringing performance into the 5-8x10^{31} range (10-15 pb^{-1}/week) by the end of FY03
  - These presentations will culminate in a presentation on the detailed FY03 plan.
- Systems presentations will include some description of activities aimed at performance enhancements beyond FY03.
  - We are starting to approach Run IIa and Run IIb as a continuous, integrated entity: "Run II"

Summary

Collider Run II is the most important activity we are engaged in at Fermilab, and we are committed to its success.

- Issues uncovered during initial Run II operations are being pursued systematically. We hope to achieve the luminosity goal established with the Main Injector project by the end of the year.
  - There is no "silver bullet"
  - Most serious underlying issues are:
    - Tevatron transfer/acceleration efficiencies, emittance dilution, and beam lifetime at 150 GeV
    - Role of long-range beam-beam
- We have seen >300% improvement in performance since January.
  - Derived from specific improvements to the complex

Summary

- There is still lots to do to achieve longer term Run II goals
  - Current priority is on establishing operations above 4×10^{31} by the end of 2002
  - Moving much beyond this will require the Recycler (and recycling?)
  - Components of the longer range Run II plan exist but are not under active pursuit other than electron cooling
    - Project manager has been assigned.
  - Achievement of $2\text{-}4 \times 10^{32}$ would allow accumulation of roughly 6-11 fb^{-1} by the start of LHC physics operations.
- We hope that the review committee will conclude that:
  - We have a good plan in place for improving performance to the level of at least 5×10^{31} (10 pb^{-1}/week) over the coming year
  - The plan will leave the accelerator complex well positioned for a further factor of two improvement in FY04